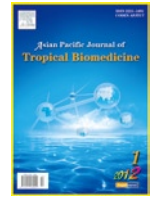




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Nutritional constituents and medicinal values of *Momordica cymbalaria* (Athalakkai) – A review

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ABSTRACT

The plant *Momordica cymbalaria* (*M. cymbalaria*) belongs to the family Cucurbitaceae, originating in tropical regions of India and South East Asia. *M. cymbalaria* Hoof. is commonly known as Karchikai (Kannada) or Athalakkai (Tamil) or Kasarakayee (Andhra Pradesh) and Kakrol (India). Athalakkai has been used in various Asian traditional medicine systems for a long time. The plant is traditionally used for the treatment of diabetes mellitus, rheumatism, ulcer, skin disease, and diarrhoea. The fruit of this plant have been reported to possess hypoglycaemic, hypolipidemic, cardio protective, hepatoprotective, nephroprotective and antioxidant properties. Owing to anthropogenic activities, such as habitat destruction due to grazing and urbanization, and poor seed viability and germination, *M. cymbalaria* is under threat of extinction. This review focuses on the cultivation, nutritional and chemical composition, as well as medicinal and therapeutic properties of this plant.

1. Introduction

Cucurbitaceae is a plant family commonly known as melons, gourds or cucurbits and includes crops like cucumbers, squashes (including pumpkins), luffas, melons (including watermelons). The family is predominantly distributed around the tropics, where those with edible fruits were amongst the earliest cultivated plants in both the old and new world. Major genera under this family are *Trichosanthes* (100 species), *Cayaponia* (60 species), *Momordica* (47 species), *Gurania* (40 species), *Sicyos* (40 species) and *Cucumis* (34 species). This is one of the most genetically diverse groups of food plants in the plant kingdom. The plants belonging to this family are frost-sensitive, drought tolerant, and intolerant to wet and poorly drained soils. Production of cucurbits seems to have increased over the time due to high demand and consumer awareness on the health benefits of cucurbit fruits.

Momordica cymbalaria (*M. cymbalaria*) (synonyms; *Momordica tuberosa* Roxb. Cogn., or *Luffa tuberosa* Roxb.) is

one of the species of cucurbitaceae family. The synonyms are *Momordica tuberosa* Roxb., or *Luffa tuberosa* Roxb. The plant is a perennial climber available only during the monsoon season and is found in the south Indian states of Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, and Tamil Nadu. The plant is a climbing annual or perennial herb with slender, scandent, branched, striate stem. The plant is traditionally used for the treatment of diabetes mellitus and also as an antiovaratory agent.

So far no review has been covered from the literature encompassing valuable attributes of *M. cymbalaria* in all dimensions. Its versatile utility as a nutritious vegetable, folk medicine and functional food ingredient provoked us to compile a comprehensive review of this multipurpose fruit on the distribution, nutritional attributes and phytochemicals composition and its medicinal properties.

2. Description

M. cymbalaria (Athalakkai).

Kingdom	<i>Plantae</i>
Superdivision	<i>Spermatophyta</i> – Seed plants
Division	<i>Magnoliophyta</i> – Flowering plants
Class	<i>Magnoliopsida</i> – Dicotyledons
Order	<i>Cucurbitales</i>

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Family	<i>Cucurbitaceae</i> – Cucumber family
Sub family	<i>Cucurbitaceae</i>
Tribe	<i>Jolifficae</i>
Subtribe	<i>Thladianthinae</i>
Genus	<i>Momordica</i>
Species	<i>cymbalaria</i> Hoof

Table 1

Proximate principles and nutrient composition of *Momordica cymbalaria* (Source[24]).

Costituent*	Athalakkai	Bitter gourd
Moisture	84.30	83.20
Crude fiber	6.42	1.70
Carbohydrate	12.60	10.60
Protein	2.15	2.10
Food energy (kcal/100 g)	3.00	60.00
Calcium	72.00	23.00
Potassium	500.00	171.00
Sodium	40.00	2.40
Iron	1.70	2.00
Copper	0.18	0.19
Manganese	0.32	0.08
Zinc	2.82	0.46
Phosphorus	0.46	38.00
Vitamin C	290.00	96.00
β Carotene	0.01	126.00

*Nutrient composition, mg/100 g.

Table 2

Phytochemical screening of leaves of *Momordica cymbalaria*[5].

Phytoconstituents	Petroleum ether	Chlorofom extract	Ethanol extract	Aqueous extract
Alkaloids	–	+	–	–
Carbohydrates	–	–	++	++
Flavonoids	–	–	++	++
Saponins	–	–	–	+
Cardiac glycosides	–	–	–	–
Anthraquinones	–	–	–	–
Tannins	–	–	–	–
Proteins	–	–	–	–
Steroids	++	++	++	–
Triterpene	++	++	++	–

Table 3

Phytochemical screening of tubers of *Momordica cymbalaria*[6].

Tests	Pet ether	Chloroform	Ethanol	Water
Alkaloids	–	–	–	–
Sterols	+	+	–	–
Triterpenes	+	+	+	–
Saponins	–	–	+	+
Flavonoids	–	–	–	–
Tannins	–	–	–	–
Fixed oils &Fats	–	–	–	–
Gums &Mucilages	–	–	–	–
Carbohydrates	–	–	+	+
Cardiac glycosides	–	–	+	+
Proteins & Amino acids	–	–	–	–

(+) Indicates respective constituent present and (–) Indicates absence of photochemical.

Table 4.

Amino acid sequences of bovine insulin and insulin isolated from *Canavalia ensiformis*, *Vigna unguiculata* and *Bauhinia variegata*[14].

Plant species	Insulin sequence
Bovine insulin α –chain	1 GIVEQCCASVCSLYQLENYCN 21
Bovine insulin β –chain	1 FVNQHLCGSHLVEALYLVCGERGFFYTPKA 30
<i>Canavalia ensiformis</i>	1 GIVEQCCASVCSLYQLENYCN 21 I–SC
<i>Canavalia ensiformis</i>	1 FVNQHLCGSHLVEALYLVCGERGFFYTPKA 30 I–LC
<i>Vigna unguiculata</i>	1 GIVEQXXASVXSLYQLENYXN 21 I–SC
<i>Vigna unguiculata</i>	1 FVNQHLCGSHLVEALYLVCGERGFFYTPKA 30 I–LC
<i>Bauhinia variegata</i> a	1 GIVEQ 5
<i>Bauhinia variegata</i> b	1 FVNQH 5

3. Morphology

The plant *M. cymbalaria*, Cucurbitaceae, originating in tropical regions of India and South East Asia. The original home of the species is not known, other than that it is a native of the tropics. The plant is a climbing annual or perennial herb with slender, scandent, branched, striate stem. The leaves is orbicular–reniform in outline, deeply cordate at the base, obtusely lobed with five–seven lobes (Figure 1a). The fruits are 20–25 mm long, pyriform with 8 sharp ridges, 24 mm \times 15mm attenuated at the apex and with the base narrowed into the curved peduncle, which is fleshy, dark green and ribbed (Figure 1b). The seeds are 4.6 mm long, ovoid shaped, smooth and shiny. Flowers are unisexual. The male flower peduncle is 5–30 mm long, filiform, puberulous, ebracteate with 2–5 flowers in racemes with a pale yellow corolla and two stamens for each flower. The female flower is solitary on a peduncle of 28 mm length (Figure 1c). The roots are woody, tuberous and perennial (Figure 1d). The plant is allowed to grow along bunds (boundary of fields), fences and even in the fields for the sake of fruits. However, no regular cultivation is practiced. A limited number of perennial tubers survive in soil and produce single plant in the next season.

4. Micro propagation

Attempts have been made to establish protocol for *in vitro* propagation of *Momordica tuberosa* (Cogn) Roxb. Using nodal segments and shoot apices obtained from field-grown mature plants. *In vitro* regeneration was achieved from nodal explants on Murashige and Skoog's (MS) medium supplemented with 6–benzyladenine (BA) at 2.22, 4.40, 6.62, and 8.90 mM and kinetin (Kn) at 2.32, 4.60, 6.92, and 9.30 mM either alone or in combination (BA + Kn). Within the ranges evaluated, the regeneration medium containing 4.40 mM BA combined with 4.60 mM Kn showed highest regeneration efficiency, with 9.00 ± 0.49 shoots per explant. Such *in vitro* regenerated shoots attained a maximum length of (10.00 ± 0.47) cm. The regeneration medium containing BA + Kn was used to subculture regenerated shoots at 4–week intervals. BA at 13.30 mM induced regeneration from shoot apex

cultures, and 75% of explants showed regeneration efficiency with (7.80 ± 0.66) cm as the mean length of shoot. Such shoots could be sub cultured on medium containing BA. Micro shoots were rooted onto MS medium supplemented with 4.90 mM indole-3-butyric acid. Regenerated plants were established in the greenhouse with 90% survival rate. The protocol is simple, rapid, and efficient for *in vitro* propagation of nodal explants and shoots apices of *Momordica tuberos*[1].

In vitro multiple shoot production from node, internode and leaf explants of *M. cymbalaria* has been reported by Nikam *et al*[2]. The maximum number of indirect regeneration of multiple shoots (9.0 ± 0.5 shoots per explants) was achieved from leaf on MS medium enriched with BA. Large scale shoot formation was achieved by repeated sub culturing of leaf callus on shoot regeneration medium. The best root induction and survival was achieved on hormone free half strength MS medium.

5. Nutritional composition

The nutrient contents of the two vegetables *M. cymbalaria* (athalakkai) and *Momordica charantia* (bittergourd) are summarized in Table 1. The calcium content of athalakkai is three times higher than that of the bitter gourd. Calcium is required for the growth of bones and teeth as well as for maintaining normal heart rhythm, blood coagulation, muscle contraction and nerve responses. The higher concentration of this nutrient in athalakkai may be exploited and used. Iron content in both the vegetables is almost the same. The ascorbic acid (Vitamin C) content of athalakkai is two times higher than that of bitter gourd. This is of interest, where there is shortage in vitamin C consumption. The content of potassium in athalakkai is also two times higher than in bitter gourd. The β carotene content in athalakkai is negligible[3]. The results of phytochemical analysis of the leaves and tubers of athalakkai were shown in Table 2 and



Figure 1. *Momordica cymbalaria*.
(a) Leaves, (b) Fruits, (c) Flowers, (d) tubers of *Momordica cymbalaria*.

3 respectively^[4,5]. Fruits are reported to contain citric acid, malic acid and vitamin C^[3].

6. Therapeutic uses

M. cymbalaria fruits were considered as tonic, stomachic, stimulant, laxative and alterative. The fruit is useful in treating gout, rheumatism and sub acute cases of the spleen and liver diseases. It has also been shown to have hypoglycaemic properties (antidiabetic) in animal as well as human studies. The fruit juice and leaf tea of *M. cymbalaria* is employed for diabetes, malaria, colic, sores and wounds, infections, worms and parasites, as an emmenagogue, and for measles, hepatitis, and fevers. Fruit pulp, leaf juice and seeds possess antihelminthic activity. Root is astringent, abortifacient, aphrodisiac and also used to treat constipation, indigestion, diabetes, diarrhoea and rheumatism. For the last few decades, the medicinal value of plants has been recognized. The extracts from many plants contain not only minerals and primary metabolites but also a diverse array of secondary metabolites, mostly with antioxidant properties. Plants belonging to *Momordica* species have been used as therapeutic agents for the treatment of diabetes mellitus. The other species of this genus, *Momordica charantia* and *Momordica foetida* have been reported to have hypoglycaemic effects^[6,7].

6.1. Antidiabetic and hypoglycaemic activity

Rao *et al*^[8] reported that *M. cymbalaria* fruit possess antidiabetic and hypoglycaemic activity. The hypoglycaemic activity of fruit powder of *M. cymbalaria* was evaluated in normal and alloxan-induced diabetic rats. The continuous treatment with *M. cymbalaria* fruit powder at the rate of 0.25 g/kg of body weight for a period of 15 days caused a significant decrease in the blood glucose levels of diabetic rats but no effect was observed in the normal treated rats. There was a significant weight loss in the diabetic rats, and the treatment with *M. cymbalaria* powder in the treated diabetic group resulted in an improvement in their body weights. The ability of the *M. cymbalaria* powder to protect the body weight loss seems to be due to its antidiabetic activity. Since alloxan treatment causes permanent destruction of β cells, *M. cymbalaria* fruit powder may produce the antidiabetic effect in diabetic rats by a mechanism other than the stimulation of insulin release from the β cells. The treatment with *M. cymbalaria* fruit powder has also enhanced the rate of glycogenesis as indicated by higher amounts of hepatic glycogen in the diabetic treated group.

Rao *et al*^[9] have also carried out experiment to state that the antihyperglycemic activity of MC was associated with an increase in plasma insulin levels. The increased level of insulin in diabetic treated rats in their study indicate that *M. cymbalaria* extracts stimulates insulin secretion from the remnant β cells or/and from regenerated β cells. The aqueous extract of *M. cymbalaria* fruit has lowering effect of blood glucose of 41.8% by using 0.5 g/kg of body weight, compared to the other organic solvent extracts of the *M. cymbalaria* in the diabetic rats. Further, they have stated

that the antihyperglycemic activity of the aqueous extract of *M. cymbalaria* fruit in diabetic rats is 26% higher after 3 h of drug administration than that of oral hypoglycaemic agent, glibenclamide.

Kumar *et al*^[10] reported that the alcoholic extract of *M. cymbalaria* has significantly decreased the serum glucose level in both normal and streptozotocin (STZ)/nicotinamide induced type II diabetic rats. Oral administration of alcoholic extract of *M. cymbalaria* (175 mg/kg, /31 days) showed significant regression of the diabetic state and restored the deranged serum glucose, cholesterol, triglycerides, serum insulin and HDL parameters in STZ induced type II diabetes. The insulin levels were significantly increased after treatment with *M. cymbalaria* both at lower and higher doses, the same might be the proposed mechanism of action for reduced glucose levels in normoglycemic rats. Therefore alcoholic extract of *M. cymbalaria* might be useful in treating type-II diabetes.

6.2. Insulin mimetic peptide

The aqueous extract of *M. cymbalaria* fruits has showed a potent anti hyperglycemic activity. The extract at a dose of 0.5 g/kg of body weight is effective for reducing blood glucose levels to near normal in the diabetic rats^[11]. A 17 kDa protein with an isoelectric point of 5.0 was identified as the active principle of antidiabetic action present in the aqueous extract of fruits of *M. cymbalaria*. It is named as M. Cy protein and found to be a novel protein by comparing its N-terminal amino acid sequence with those in the protein data bank. It did not produce any hypoglycemia in either normal or diabetic rats. The results suggest that 'M.Cy protein', present in the fruits of *M. cymbalaria* is an effective antihyperglycemic active principle in STZ induced diabetic rats at a dose of 2.5 mg/kg of body weight^[12]. A comparison between the N-terminal sequence of M.Cy protein and α chain of human insulin was made since both are anti hyperglycemic proteins.

Insulin α chain	Gly Ile Val Glu Gln Cys Cys Thr Ser Leu Tyr-
M.Cy protein	Gly Leu Glu Pro Thr Thr Thr-

Similar such insulin mimetic peptide was reported in its related counterpart *M. cymbalaria*. And also in other plant species namely *Canavalia ensiformis*, *Vigna unguiculata* and *Bauhinia variegata*^[13], the presence of insulin like peptide have been reported and their amino acid sequences were compared with bovine insulin (Table 4).

6.3. Hepatoprotective activity

Kumar *et al*^[14] reported the antioxidant and hepatoprotective activity of ethanolic extract of tubers of *Momordica tuberosa* against CCl₄ induced liver injury in rats. CCl₄ is metabolised by Cyp 450 enzyme system to trichloromethyl radical (CCl₃). This in turn reacts with molecular oxygen and gets converted to trichloromethyl peroxy radical. This radical forms covalent bonds with sulfhydryl group of several membrane molecules like reduced glutathione leading to this depletion and causes lipid peroxidation. The lipid peroxidation initiates a cascade of reactions leading to tissue necrosis. The antioxidant

property of ethanolic extract of tubers of *Momordica tuberosa* prevented the formation of trichloromethyl peroxy radical there by reducing tissue damage.

Kumar *et al*^[15] reported the hepatoprotective activity of 70% ethanol extract of tubers of *Momordica tuberosa* against thiacetamide (100 mg/kg of body weight) induced hepatic damage in albino rats.

6.4. Cardioprotective effect

Koneri *et al*^[16] has reported that *M. cymbalaria* (500 mg/kg of body weight) prevented the alterations in marker enzymes of myocardial infarction, and oxidative stress along with uric acid. Myofibrillar alterations such as myocytosis and myofibrillar degeneration are reported in isoproterenol treated rats. Cardiac sections of the isoproterenol treated animals showed infiltration of inflammatory cells and continuity in the muscle fiber was lacking suggesting an irreversible cell injury. Rats pretreated with *M. cymbalaria* showed normal myofibrillar structures with striations and revealed a marked protection by the extract against myocardial necrotic damage. Administration of isoproterenol raised LDL cholesterol and decreased HDL cholesterol level in the serum. An increase in concentration of total cholesterol and LDL cholesterol, and a decrease in HDL cholesterol are associated with raised risk of myocardial infarction. High level of circulating cholesterol and its accumulation in heart tissue is accompanied with cardiovascular damage. *M. cymbalaria* elevated the HDL level and decreased the LDL cholesterol level. There is a growing body of evidence from epidemiologic, clinical, and laboratory data indicating that elevated triglyceride levels are an independent risk factor for cardiovascular disease. Hypertriglyceridemic patients are at a risk for cardiovascular disease often develops a lipoprotein profile characterized by elevated triglyceride, dense LDL, and low HDL cholesterol which causes myocardial membrane damage. Hypertriglyceridemia observed in isoproterenol treated rats is clinically reported in ischemic heart disease. Pretreatment with *M. cymbalaria* prevented the elevation of triglycerides cholesterol and LDL in serum, signifying that the myocardial membrane is intact and not damaged. Antihyperlipidemic, antioxidant and antidiabetic activity along with cardioprotective properties of *M. cymbalaria* adds to the accumulating evidence for therapeutic potential of this plant

6.5. Anti diarrhoeal activity

Swamy *et al*^[17] have reported that the methanol extract of fruit of *Momordica cymbalaria* exhibited significant anti-diarrhoeal activity against castor oil induced diarrhoea in rats. The extract had a similar activity as that of anti diarrhoeal drug diphenoxylate, when tested at 200, 400 & 600 mg/kg and statistically significant reduction in the frequency of defecation and the wetness of the fecal droppings when compared to untreated control rats.

The methanol extract of *M. cymbalaria* (MEMC) significantly inhibited the prostaglandin E₂ (PGE₂) induced intestinal fluid accumulation (enter pooling). It has been shown that E type of prostaglandin cause diarrhoea in experimental animals

as well as human beings. Their mechanism has been associated with dual effects on gastrointestinal motility as well as on water and electrolyte transport. PGE₂ also inhibit the absorption of glucose a major stimulus to intestinal adsorption of water and electrolytes. These observations tend to suggest that MEMC reduced diarrhoea by inhibiting PGE₂ induced intestinal accumulation of fluid.

6.6. Anti ulcer activity

The aqueous extract of *Momordica tuberosa* is proved to have anti ulcer property. The reduction in non protein sulphhydryls concentration, gastric content, haemorrhage and ulceration in the ulcer induced Wistar rats suggested that the anti ulcer activity of the aqueous extract of *Momordica tuberosa* is due to the presence of polyphenolic constituents^[18].

6.7. Anti microbial activity

The extracts (Petroleum ether, chloroform, ethanol, and aqueous) of *M. cymbalaria* has very good inhibitory effect against *Staphylococcus aureus*, *Klebsiella pneumonia*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Aspergillus niger* when compared to standard antibiotics. The standard antibiotics zone of inhibition was less than the extracts of *M. cymbalaria* indicates that this plant fight against these organisms effectively^[19].

6.8. Nephroprotective activity

Kumar *et al*^[20] reported that the tubers of *Momordica tuberosa* possesses marked nephroprotective activity and could have promising role in the treatment of acute renal injury induced by nephrotoxins. This activity may be attributed to its antioxidant property.

6.9. Anti cancer activity

The methanol extract of aerial parts of *M. cymbalaria* Hook f (200 mg/kg of body weight) has been showed significant anticancer activity as compared to standard cyclophosphamide against ehrlich ascites carcinoma induced cancer in mice^[21].

7. Anti implantation and anti ovulatory activity

Koneri *et al*^[22] have reported that anti implantation activity of ethanolic root extract of *Momordica tuberosa* in rats and it may not be due to estrogenic or progestrogenic activities.

Koneri *et al*^[23] reported the antiovolatory and abortifacient potential of the ethanolic extract of root of *M. cymbalaria* on rats. The estrous cycle in the rats treated with extract (250 and 500 mg/kg) showed a decrease in the duration of estrous and the metestrous phases. It was also characterised by a prolongation of the proestrous phase. The prolongation of the proestrous phase indicates that maturation of the follicle in the preovulatory phase was delayed, leading to non-maturation of graffian follicle. Non-availability of matured graffian follicle was indicated by reduction in the

estrous and the metastrous phases. Therefore, ovulation was inhibited. Ethanolic extract at 500 mg/kg showed 100% abortifacient activity, while 250 mg/kg did not show abortifacient activity.

8. Conclusion

Current therapy for diabetes involves oral antidiabetic drugs and insulin administration; these approaches neither mimic the way insulin secreted by native β islets for the regulation of glucose in real-time nor provide tight control of blood glucose to avoid late complications of the disease. Transplantation of islet cells isolated from a donor pancreas has been shown to control glucose levels successfully. Being less invasive, it is a better alternative to pancreas transplantation yet scarcity of donors, maintenance of islet functions such as cell growth and survival *in vitro*, and concern over the adverse effect of lifelong immunosuppressant used to prevent graft rejection precludes the benefits of islet transplantation from becoming universally acceptable. *M. cymbalaria* not only exhibits antihyperglycemic activity but also anti diabetic activity with the possible involvement in regeneration of β cells and by increasing insulin level. Profiling of phytochemicals by LC–MS and further structural elucidation of compounds by techniques like NMR will pave way for to identify the candidate compounds and further to understand the mechanism of action by *in vitro* and *in vivo* experiments may be of future areas of research to find a better food based therapy to treat diabetes without side effects of antidiabetic drugs.

Conflict of interest statement

We declare that we have no conflict of interest.

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